भारतीय मानक
Indian Standard

IS 11228 : 2023

द्रवचालित फाटक पेंच उच्चालक की डिजाइन के लिए अनुशंसाएँ

(पहला पुनरीक्षण)

Recommendations for Design of Screw Hoists for Hydraulic Gates

(*First Revision*)

ICS 93.160

BIS 2023

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
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March 2023 **Price Group 7**

Hydraulic Gates and Valves Sectional Committee, WRD 12

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Water Resources Division Council.

The controlled release of water to canals is made by the use of gates provide don head regulators, cross regulators, control gates in conduits and tunnels or in the body of a dam. For the operation of such small size low head gates, generally the screw hoists are used.

A screw hoist is simple in construction and consists of a cast iron or fabricated pedestal resting on a platform. A screw stem passes through the pedestal and platform and is connected to the gate by means of nuts/pins. The screw stem engages with a long threaded bronze nut which freely rotates in the pedestal, where thrust bearings are provided. As the nut rotates, the stem is lifted up or lowered down depending upon the direction of rotation of nut and the gate gets lifted or lowered down. The source of power for the rotation of nut is a rotating crank (in case of hand operated screw hoists and electric motor in case of power-driven screw hoists), set of spur gears, bevel pinion and bevel gear.

The screw hoist is used when a positive thrust is required to close the gate. The screw hoist is also used in case of low capacity manually operated hoist where it may not be necessary to provide any other electrically operated hoisting system. It is very compact and more economical as compared to other types of hoists. The use of screw hoist will be limited where gate vibrations are involved because of the fact that screw threads will get damaged under those conditions. The efficiency of the screw is also low. The screw hoist is used for gates with single or double point consideration.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to the practices in the field in this country.

This standard was first published in 1985. The first revision of this standard has been brought out to update the standard in the light of experience gained and the latest trends in design. The major changes incorporated on this revision are:

a) Updation of Fig. 1 and 2;
b) Insertion new Figure on typical arrangement of stem where gate is self-closing;
c) Updation of Table 1; and
d) Coefficient of friction under different conditions.

The composition of the committee responsible for the development and approval of this standard is listed in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDATIONS FOR DESIGN OF SCREW HOISTS FOR HYDRAULIC GATES

(First Revision)

1 SCOPE

This standard lays down guiding principles for design of manually operated and motor-operated screw hoists used for operation of hydraulic gates.

2 REFERENCES

The Indian Standards listed below contain provisions which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 210 : 2009	Grey iron castings — Specification (*fifth revision*)
IS 318 : 1981	Specification for leaded tin bronze ingots and castings (*second revision*)
IS1030 : 1998	Carbon steel castings for general engineering purposes — Specification (*fifth revision*)
IS 2004 : 1991	Carbon steel forgings for general engineering purposes — Specification (*third revision*)
IS 2048 : 1983	Parallel keys and keyways (*second revision*)
IS 2062 : 2011	Hot rolled low, medium and high tensile structural Steel (*seventh revision*)
IS 2693 : 1989	Power transmission — Bush type flexible coupling (*second revision*)
IS 4218	ISO General Purpose Metric Screw Threads
(Part 1) : 2001/ ISO 68-1 : 1998	Basic and design profiles (*second revision*)
(Part 2) : 2001/ ISO 261 : 1998	General plan(*second revision*)
(Part 3) : 1999/ ISO 724 : 1993	Basic dimensions (*second revision*)
(Part 4) : 2001/ ISO 262 : 1998	Selected sizes for screws, bolts and nuts (*second revision*)
IS 6603 : 2001	Stainless steel bars and flats — Specification (*first revision*)
IS 6938 : 2005	Design of rope drum and chain hoists for hydraulic gates — Code of practice (*second revision*)

3 GENERAL

Typical general arrangement of screw hoist and the connection of items are shown in Fig. 1 to 4.

4 HOIST CAPACITY

4.1 The hoist capacity shall be determined by taking into consideration the following forces which might be required to be overcome:

a) Weight of the gate along with all its components including gatestem, intermediate stems, etc;

b) All frictional forces comprising:

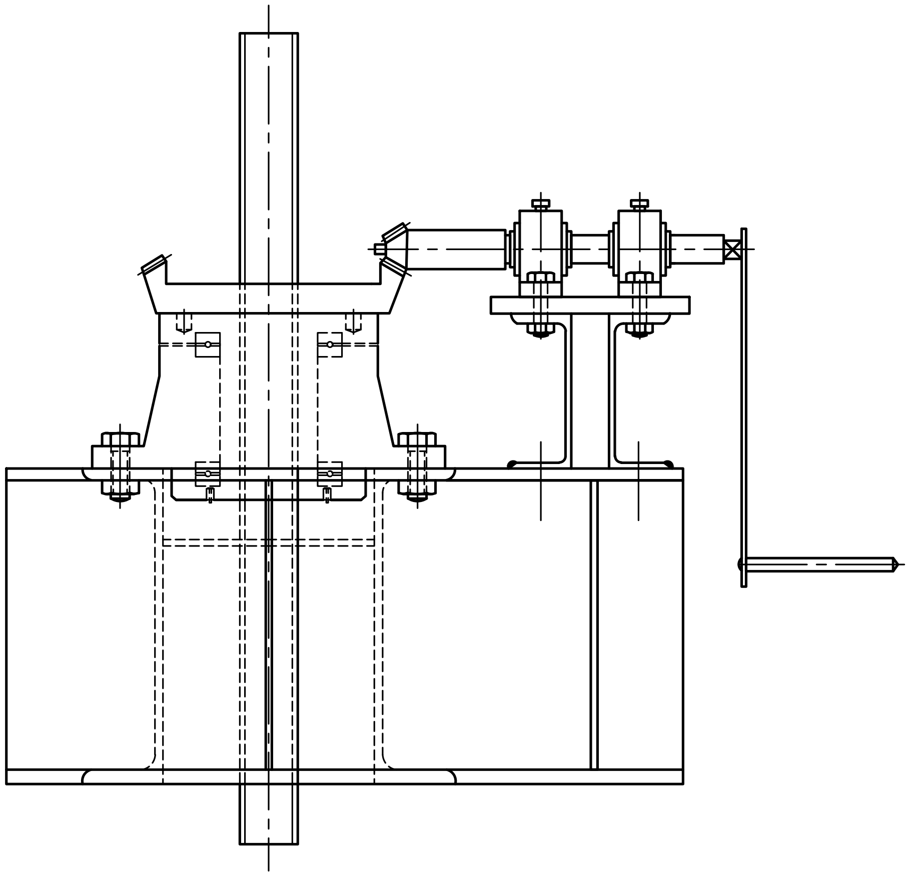
   1) Wheel friction or slide friction;
   2) Guide friction; and
   3) Seal friction.

c) Any hydro-dynamic load, like down pull force/uplift etc;

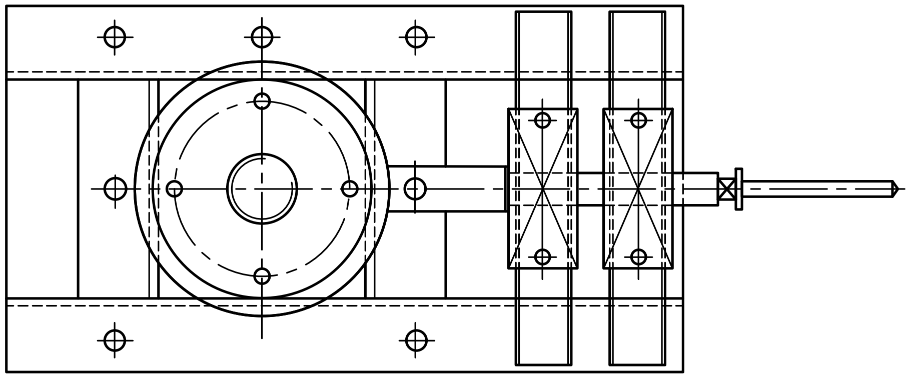
d) Silt and ice load wherever encountered;

e) Seating load as prescribed in **4.4**; and

f) Any other consideration specific to a particular site.



ELEVATION



PLAN

FIG. 1 TYPICAL ARRANGEMENT FOR MANUAL OPERATED SCREW HOIST

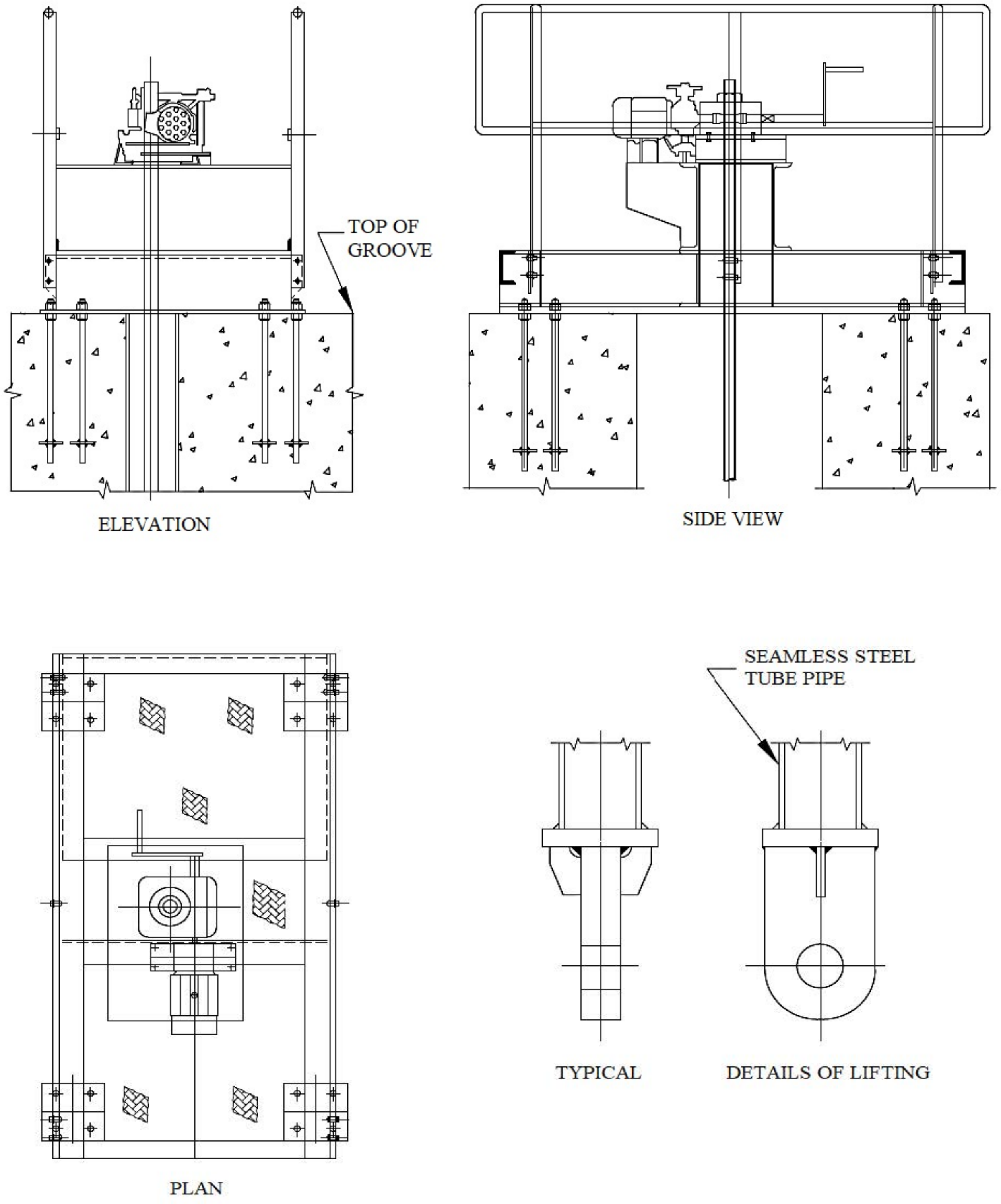


FIG. 2 TYPICAL ARRANGEMENT OF MOTOR DRIVEN SCREW HOIST USING SPECIAL WORM GEARBOX, WORM WHEEL MOUNTED ON THRUST BEARINGS AND WORM SHAFT WITH A PROVISION OF POWER CONNECTION ON ONE SIDE AND MANUAL HANDLE CONNECTION OTHER SIDE

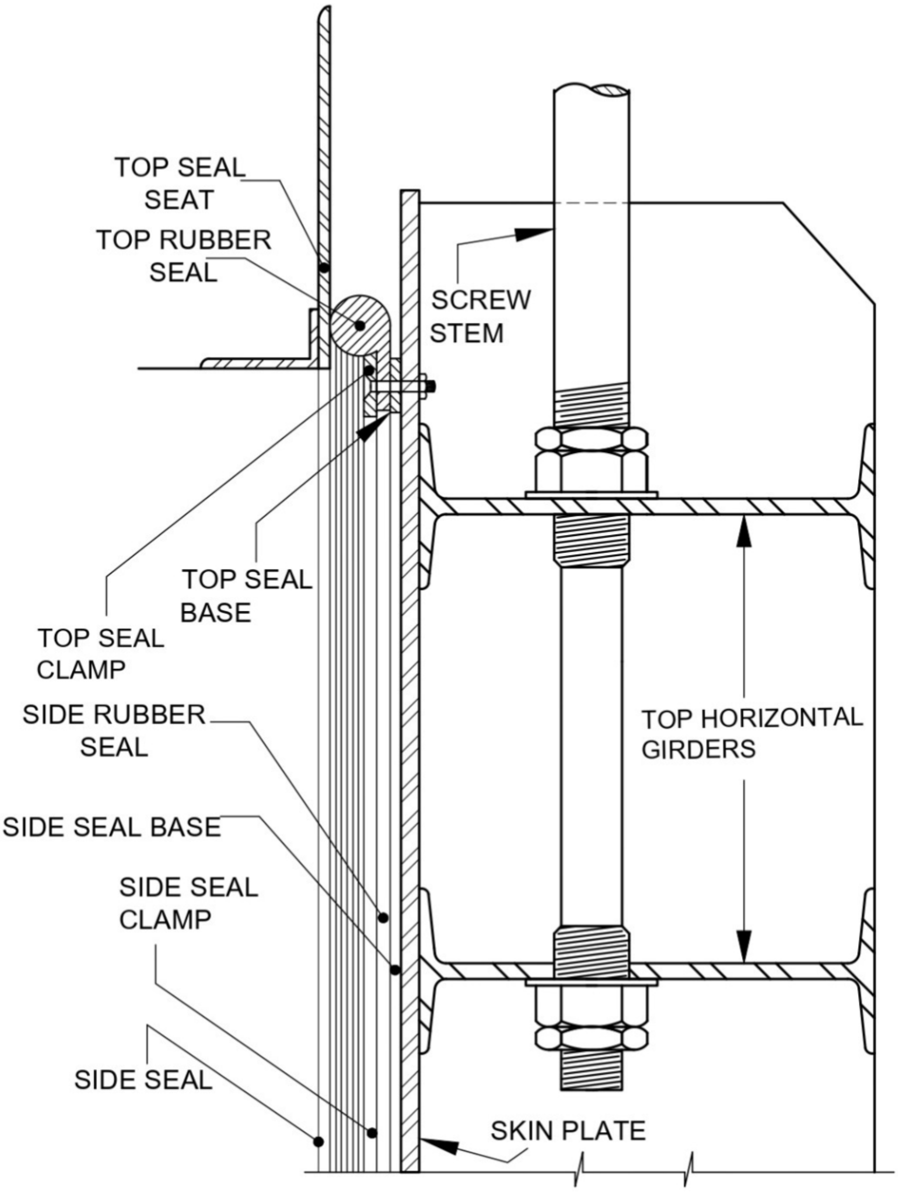
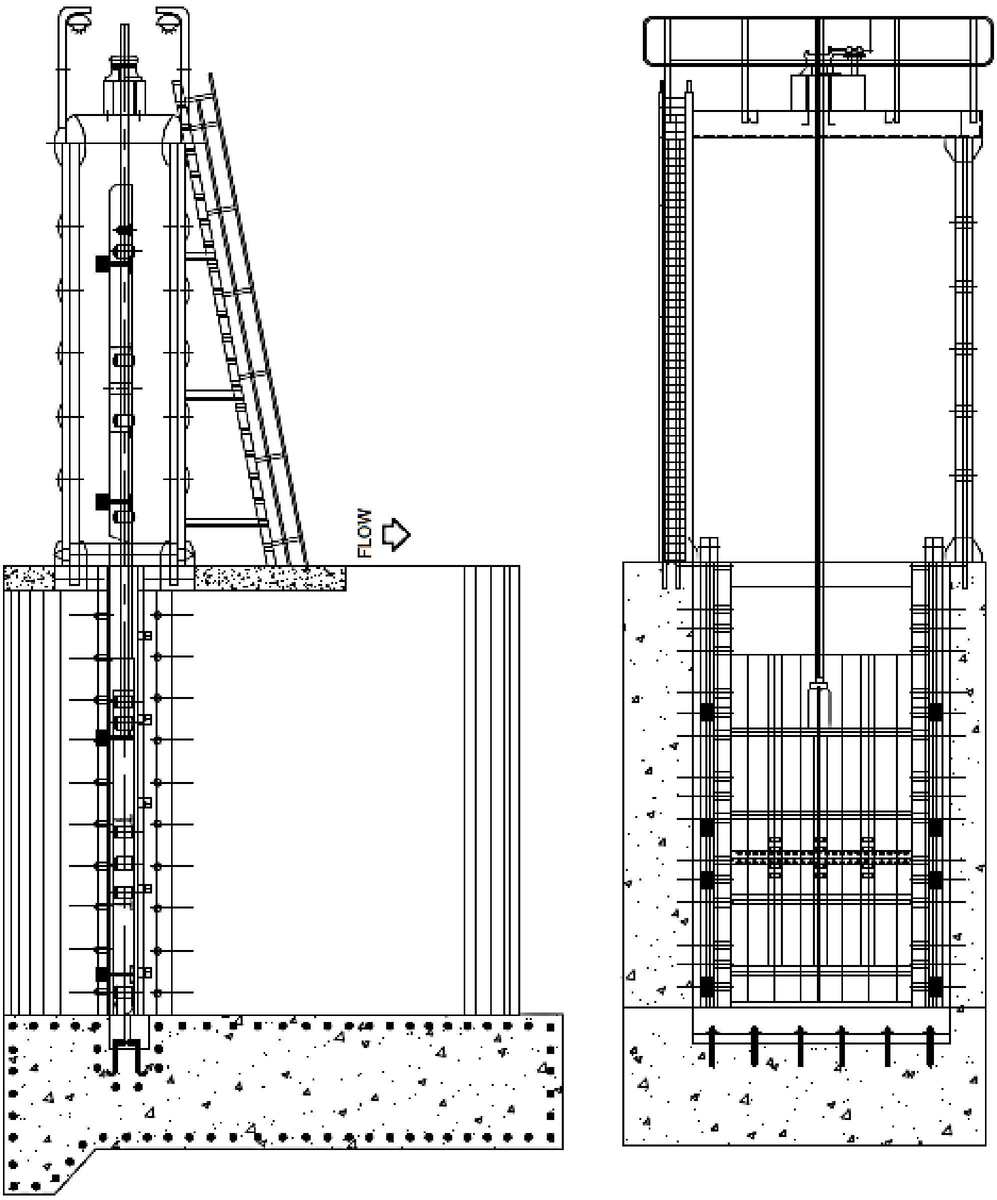


FIG. 3 TYPICAL CONNECTION OF STEM TO GATE



END VIEW ELEVATION

FIG. 4 TYPICAL ARRANGEMENT OF STEM WHERE GATE IS SELF-CLOSING

4.2 The worst combination of the above forces, during either lowering cycle or raising cycle, shall be considered.

4.3 The net hoist capacity shall be obtained by increasing the hoist capacity thus arrived at by 20 percent to provide for the reserve hoist capacity.

4.4 The gate may be required to be given an additional downward thrust to make it seat properly on the sill to achieve the proper seal compression. While calculating the total hoist capacity during the closing cycle, the necessary closing/seating load required, when the gate is about to seat on the seal, shall be greater than the value given below:

Type of Gate	*Maximum Seating Load*
Low head gates	2.5 kN/m
Medium head gates	5.0 kN/m
High head sluice gates	10.0 kN/m

4.5 The usual lifting speed of the motor-operated screw hoist shall be 200 mm to700 mm per minute and for the manually operated screw hoist shall be governed by provision contained in **6.10**. However, other values may be adopted depending upon the requirements.

5 MATERIAL AND DESIGN STRESSES

5.1 The recommended materials and design stresses for various components of screw hoist are given in Table 1.

Where any material has not been specified, it shall be the best available for the purpose for which it is intended to be used and shall conform to the relevant Indian Standards.

Table 1 Material and Design Stresses for the Components of Screw Hoists
(*Clause* 5.1)

Sl No.	Component/ Part	Recommended material	Reference	Allowable design stresses		
				Direct Bending	*Shear*	*Bearing*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Stem	Forged steel	IS 2004	0.4 YP	0.28 YP	0.75 YP
		Stainless steel	IS 6603			
ii)	Stem nut	Leaded tin bronze	IS 318	—	0.03 UTS	0.04 UTS
		Aluminum Bronze	IS 305	—	0.03 UTS	0.04 UTS
iii)	Gear & pinion	Forged steel	IS 2004	0.4 YP	0.28 YP	0.75 YP
		Carbon steel	IS 2062			
		Cast steel	IS 1030			
		Carbon steel casting	IS 2707			
iv)	Shaft keys	Forged steel	IS 2004	0.4 YP	0.28 YP	0.75 YP
v)	Gear box base and hoist bridge	Structural steel	IS 2062	0.67 YP	0.47 YP	0.75 YP
vi)	Pedestal	Structural steel	IS 2062	0.67 YP	0.47 YP	0.75YP
		Cast steel	IS 1030			
		Cast iron	IS 210			

NOTE—For breakdown torque condition, the allowable stress shall be taken as 80 percent of the yield point stress of the material.

6 DESIGN OF MECHANICAL COMPONENTS

6.1 General Requirements

6.1.1 The various components of hoist mechanism shall be so proportioned as to take care of the worst load combination coming on individual component.

6.1.2 The stress in various components of hoist shall be checked for maximum power transmission in these components, taking into account the permissible stresses as given in the relevant clauses.

6.1.3 All the hoisting machinery parts shall be checked for static as well as dynamic loads.

6.1.4 The combined stresses in various components shall be found by the following formulae:

a) $\sigma_c = \sqrt{\sigma_1{}^2 + \sigma_2{}^2 - \sigma_1\sigma_2 + 3\tau^2)}$,

b) $\sigma_s = \frac{1}{2}\sqrt{\sigma_1{}^2 + 4\tau^2}$, and

c) $\sigma_t = \frac{1}{2}(\sigma_1 + 2\sigma_s)$

where

σ_c = maximum combined stress, in N/m^2;

σ_s, σ_t = maximum combined shear and tensile stresses, in N/m^2;

σ_1, σ_2 = tensile/compressive stresses, in N/m^2; and

τ = shear stresses in N/m^2.

6.2 Stem

6.2.1 *General*

The stem shall normally be made of forged steel or corrosion resistant steel. It may be galvanized or nickel/chrome plated in the unthreaded portion, if so required.

6.2.2 The stem shall be provided with standard metric thread conforming to IS 4218 at one end for connection with the gate. It is normally connected to the horizontal girders and shall be required to be tightened against a minimum of two girders as per the arrangement shown in Fig. 3. The bottom end shall be provided with an additional lock nut. In case the gate does not require positive thrust for closing, pin jointing the stem to the gate may be considered, as shown in Fig 4.

6.2.3 Standard square threads or acme threads shall be cut on the stem at the other end for transmission of power. The minimum length for which the threads may be provided shall be the sum of the following:

a) Total lift of the gate;

b) Length of the nut in contact with the stem; and

c) Extra allowance of 300 mm.

More than one start of the screw threads shall be provided in order to achieve quick linear movement.

6.2.4 The screw stem rod shall be designed for direct torsional compressive load by taking the root diameter at the minimum cross-section. The diameter so arrived at shall be checked for torsional shear stress, buckling and for combined maximum shear and maximum tensile compressive stresses. Suitable supports may be provided at intermediate points, if required.

Alternatively stem made from suitable seamless pipe with rigid coupling in between may be provided.

6.2.5 For calculating the torque transmitted by the screw threads the following formula may be used.

$$T = P \times \frac{d}{2}\left[\frac{\pi\,\mu\,\mathrm{d}\sec\beta + \mathrm{L}}{\pi\,\mathrm{d} - \mu\,\mathrm{L}\sec\beta}\right]$$

where

T= torque transmitted;

P = hoist capacity;

d = pitch circle diameter of threads;

μ = co-efficient of friction;

L = lead of the screw threads; and

β = half the included angle of the threads.

NOTE — In the case of parallel sides of square threads, the term 'Secβ' may be omitted from the formula.

6.3 Nut

6.3.1 *General*

The nut, through which the power is to be transmitted to the stem, shall generally be of a material having lesser wear resistance then the material of the stem.

6.3.2 Square or acme threads matching with those provided on the screw stem shall be provided on the inner surface of the nut. The total number of threads to be cut on the nut shall be calculated on the basis of the total bearing area to be provided. The bearing pressure on the threads of nut shall not exceed 0.04 UTS. The total length of the nut shall also be governed accordingly.

6.3.3 The number of threads provided on the basis of the bearing stress shall also be checked for shear stress at the threads cross section. The minimum outside diameter of the nut shall be at least twice the minimum inside diameter.

6.3.4 *Efficiency of Transmission*

The efficiency of the power transmission between the nut and stem shall depend on the type of threads used. The following formula may be used for calculating the transmission efficiency:

i) For square threads

$$\eta = \frac{\tan\alpha\,(1 - \mu.\tan\alpha)}{(\tan\alpha + \mu)}$$

ii) For acne threads

$$\eta = \frac{\tan\alpha\,(1 - \mu.\sec\beta.\tan\alpha)}{(\tan\alpha + \mu.\sec\beta)}$$

where

η = efficiency;

α = helix angle of the screw threads;

β = half the included angle for acme threads; and

μ = coefficient of friction.

6.4 Gearing

6.4.1 *General*

Any of the following gear system or a suitable combination of these may be used in the screw hoist:

a) Spur gears;
b) Bevel gears; and
c) Worm and worm wheel

6.4.2 *Design of Spur Gears*

Unless more accurate methods are applied and called for, the spur gears shall be designed according to the formula given below:

$$\sigma_{root} = \frac{p \times q}{f \times m}$$

where

σ_{root} = stress in N/mm^2 at root of gear;
p = tooth pressure or load, in N;
q = strength factor, as indicated in Table 2;
f = face width, in mm; and
m = module, in mm

6.4.2.1 *General values of coefficient of friction* (μ) *between nut and screw*

The Coefficient of friction (μ) depend upon various factors like material of screw and nut, workmanship in cutting threads, lubrication, bearing pressure, rubbing speeds etc. The value of μ does not vary much with load or rubbing speeds except for different combinations of material and under sharing conditions. The different values of μ for steel screw and bronze nut under different conditions are shown in Table 3.

Table 2 Value of Strength Factor in Calculation of Stress in Tooth at Root (External Tooth) at 20° and 14.5° Full Depth Involute System

(*Clause* 6.4.2)

Sl No.	**Number of Teeth on Gear/Pinion**	***q* value**	
		20°	**14.5°**
(1)	(2)	(3)	(4)
i)	12	4.6	—
ii)	13	4.35	5.38
iii)	14	4.10	5.22
iv)	15	3.90	5.07
v)	16	3.75	4.93
vi)	17	3.60	4.80
vii)	18	3.50	4.68
viii)	21	3.3	4.37
ix)	24	3.2	4.13
x)	28	3.1	3.90
xi)	34	3.0	3.70
xii)	40	2.9	3.50
xiii)	50	2.8	3.40
xiv)	65	2.7	3.27
xv)	80	2.6	3.18
xvi)	100	2.5	3.10
xvii)	Above100	2.5	2.22

NOTE —Intermediate values may be interpolated.

Table 3 Coefficient of Friction Under Different Condition

(*Clause* 6.4.2.1)

Sl No.	**Condition**	**Average (*μ*)**	
		Starting	*Runnig*
(1)	(2)	(3)	(4)
i)	High grade material and workmanship with good running conditions	0.14	0.10
ii)	Average quality of materials & workmanship and average running conditions	0.18	0.13
iii)	Slow & infrequent motion with indifferent lubrication or newly machined surfaces	0.25	0.15

6.4.3 *Design of Bevel Gears*

6.4.3.1 For design of the bevel gears two additional weighing factors shall be used in the above formula. These are the bevel factor and the velocity factor. These are defined below:

6.4.3.2 The bevel factor shall be calculated by the formula:

$$\delta = \frac{C_d}{C_d - f}$$

where

δ = bevel factor,
C_d = cone distance of the bevel gears, and
f = face width.

6.4.3.3 The velocity factor shall be calculated by the following formula:

$$\omega = \frac{185}{185 + V_p}$$

where

ω = velocity factor, and

V_p = peripheral velocity in m/s at the pitch circle diameter.

6.4.3.4 The formula in **6.4.2** for calculating root stress of the gear shall, therefore, be modified as:

$$\sigma_{root} = \frac{p \times q}{f \times m} \times \frac{\delta}{\omega}$$

6.4.4 Standard worm or helical reducer, if used, for the first stage reduction at the drive unit, shall be of high grade suitable for the service intended. Rating and efficiency of the reducer used in calculation shall be as per manufacturer's recommendations.

6.5 Shafts, Key and Keyways

6.5.1 *General*

The shafts shall be designed for appropriate load/torque that is being transmitted. Shafts shall have ample strength and rigidity and adequate bearing surfaces. They shall be finished smoothly and provided with suitable changes of cross-section for easy assembly and disassembly.

6.5.2 *Dimensioning of Shafts*

In dimensioning the shafts with ratio of length/diameter greater than 50, the angle of twist and the revolutions/minute shall be taken into account, in addition to simple bending, pure torsion, or the combined effect of bending and torsion. The twist that shall be permitted is ¼ to ⅓ degrees per meter. Linear deflection in the shaft shall not exceed 1.0 mm/m length.

6.5.3 All keys and keyways shall be designed in accordance with IS 2048. Keyways shall not be extended into the bearings.

6.6 Bearings

6.6.1 *General*

All the running shafts shall be provided with ball, roller or bush bearings. Selection of bearings shall be done on consideration of duty, load and speed of the shaft. Life of ball and roller bearings shall be calculated in accordance with the manufacturer's recommendations. All bearings shall be easily accessible for lubrication and/or replacement.

6.6.2 *Thrust Bearings*

The special thrust bearings required for taking the entire hoisting/lowering load shall be provided between the nut and the pedestal body.

6.7 Couplings

6.7.1 All couplings shall be of forged steel, cast steel or cast iron and shall be designed to transmit the maximum torque that may be developed (*see* IS 2693).

6.7.2 Solid couplings shall be aligned in such a way that they meet accurately. Flexible couplings shall be initially aligned with the same accuracy as solid couplings.

6.8 Gear Boxes

6.8.1 Gear boxes shall be of rigid construction fitted with inspection covers and lifting handles, where necessary. The gear boxes shall be so designed that the gears may be easily removed or replaced, and shall be such that the gears remain adequately lubricated. In case of oil lubrication, facilities for oil filling and draining, connection for oil level indicator and adequate breathing arrangement shall be provided, wherever necessary. The gear boxes shall be mounted on a level surface.

6.8.2 The gear box shall be made of cast iron or cast steel or fabricated from mild steel.

6.9 Pedestal

6.9.1 The pedestal shall be fabricated or cast and shall be mounted on hoisting platform. The pedestal shall be designed as a column to prevent crippling due to total hoist load and shall preferably have tapered sides in order to achieve greater stability. The center line of the operating handle shall be maintained at a height of 900 to 1000 mm from the floor.

6.10 Manual Operation

6.10.1 The manual operation arrangement shall be so designed that the continuous effect per man does not exceed a crank force of 100 N at 400mm crank radius at a continuous rating of 24 revolutions per minute.

6.10.2 Hoists of capacity up to 7.5 tones may normally be provided with only manual operation arrangement unless otherwise agreed upon between the supplier and the purchaser. However, hoists of larger capacities provided with electrical operation may also be provided with an emergency hand operation arrangement.

6.10.3 In case of electrically operated hoists, suitable electrical interlocks shall be provided to prevent inadvertent operation by electrical power when the manual drive is engaged.

6.11 Gate Position Indicator

6.11.1 A separate indicator of the circular dial type or vertical scale type shall invariably be provided for each gate to show the gate position at any time. The dial or scale shall be made of a non-rusting metal or of enameled plate or thick plastic sheet. Permanent, prominently visible markings shall be made on the dial to read every 1/10 of a meter. The gate position of 'closed', 'open' and 'fully raised' shall also be marked on the dial. The indicator point shall be made of non-rusting metal.

Suitable locking system shall be provided to limit the over travel in lowering cycle to avoid bending/ failure of stem.

6.12 The design of all the mechanical components shall be checked for breakdown torque condition.

NOTE — The stresses developed in the mechanical components under breakdown torque condition shall not exceed 30 percent of the yield point for that material.

7 ELECTRICAL EQUIPMENT

7.1 General

All electrical equipment's shall be suitably protected from moisture, condensation, corrosion, etc., by providing weatherproof covers and electrical heaters, wherever necessary. All equipment shall be of the best quality conforming to relevant Indian Standards.

7.2 Efficiency of System

7.2.1 The usual values of efficiencies adopted for the various elements of hoisting mechanism are given in Table 4. The overall efficiency of the system, which is the product of individual efficiencies of elements, shall then be worked out. This overall efficiency of the system shall be used in calculating capacity of the electric motor.

7.3 Provision of all electrical equipment such as, motors, electromagnetic brakes, limit switches and control equipment, such as control panels, indicator lamps, relays, switches, starters, shall be in accordance with IS 6938.

7.4 Remote control equipment, if required, shall be provided to enable the operation of gates from some remote control room. Gate position indicators, suitably interlinked with local control panel, may also be provided in the remote control room.

7.5 Alternative source of electrical supply may be provided for important projects, if considered necessary

Table 4 Efficiency of Various Components of Hoisting Mechanism
(*Clause* 7.2.1)

Sl No. (1)	Particulars Of Elements (2)	Starting Efficiency (3)	Running Efficiency (4)
i)	Each set of spur gears	93 percent	95 percent
ii)	Each set of helical gears	95 percent	98 percent
iii)	Each set of bevel gears	91 percent	93 percent
iv)	Standard drive such as worm, reducers, helical gears reducers, etc.	As per manufacturer's recommendations	
v)	Electric motors	As per manufacturer's recommendations	
vi)	Power screws	As calculated in **6.3.4**	

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Hydraulic Gates and Valves Sectional Committee, WRD 12

Organization	*Representative*(*s*)
NHPC Limited, Faridabad	Shri M. K. Singh, General Manager (Mech) (C***hairperson***)
Bhakra Beas Management Board, Punjab	Shri K. K. Singh Executive Engineer, Mech. Division (*Alternate*)
Bharat Heavy Electricals Ltd, Bhopal	Shri Harish Kumar, Senior Manager (Design) Mohd Waliullah, Manager (Design) (*Alternate*)
Central Electricity Authority, New Delhi	Shri R. K. Rustogi Shri M. K. Khandelwal (*Alternate*)
Central Water & Power Research Station, Pune	Shri R. S. Kankara Shri Rajkumar, Sc B (*Alternate*) Dr K.C. Sahu, Sc C (*Alternate*)
Central Water Commission, New Delhi	Director, Gates (E & NE) Director, Gates (NW & S.) (*Alternate*)
Department of Water Resources, Govt of Odisha	Shri Debi Prasad Pattnaik , GM (Mech) Shri Manoj Kumar Sharma (*Alternate*)
Himachal Pradesh Power Corporation Ltd, Distt Mandi	Shri R. P. Sharma Shri Ram Krishna Kaundal (*Alternate*)
Indian Institute of Technology Roorkee	Dr K. S. Hari Prasad Prof R. P. Saini (*Alternate*)
Irrigation Research Institute, Roorkee	Chief Engineer (Design) Shri Naveen Singhal, Superintending Engineer (*Alternate*) Shri Sharad Kumar, Assistant Engineer (*Alternate*)
Jaypee Infra Ventures, Noida	Shri V. K. Gupta
NHPC Limited, Faridabad	Shri Rajesh Kumar DGM (Civil) Shri Baboo Lal Tyagi, DGM (Civil), (*Alternate*) Shri Punit Masiwal, DM (Mech.), (*Alternate*)
NTPC Limited, New Delhi	Shri Naveen Chandra Pant Shri Sujeet Kumar (*Alternate*)
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Precision Infratech Limited, Ahmedabad	Shri Nalin Vibhakar Shri Dheeraj Vania (*Alternate*)
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Texmaco Limited, Kolkata	Shri Udayan Banerjee Shri Alok Kumar Singh (*Alternate*)
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BIS Directorate General	SHRI R. BHANU PRAKASH, SCIENTIST 'E'/ DIRECTOR AND HEAD (WATER RESOURCES DEPARTMENT) [REPRESENTING DIRECTOR GENERAL (*Ex-Officio*)]

Member Secretary
SHRI DUSHYANT PRAJAPATI
SCIENTIST 'D'/ JOINT DIRECTOR
(WATER RESOURCES DEPARTMENT) , BIS

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This Indian Standard has been developed from Doc No.:WRD 12 (17639).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Southern : C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113 — 2254 1442, 2254 1216

Western : Plot No. E-9, Road No.-8, MIDC, Andheri (East), Mumbai 400093 — 2821 8093

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